Volume 17 November-December *Number 8*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication Requirements of Air, Refrigeration and Gas Compressors

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

TEXACO RECOMMENDATIONS FOR COMPRESSOR CYLINDER LUBRICATION

AIR COMPRESSOR SERVICE

Low Pressures or Temperatures	TEXACO CAPELLA OIL, or TEXACO CETUS OIL
Medium Pressures or Temperatures	TEXACO ALCAID OIL
High Pressures or Temperatures	TEXACO ALGOL OIL, or TEXACO URSA OIL
Diesel Engine Air Compressors	TEXACO URSA OIL, or TEXACO URSA OIL C
Air Cylinders of Dry Vacuum Pumps	TEXACO ALCAID OIL, or TEXACO URSA OIL
Blowing Engines	TEXACO PELICAN OIL, or TEXACO ALTAIR OIL

Recommendations as above can at best be only approximate. It must be remembered that pressures, temperatures, clearances and operating speeds, or various combinations of these may differ widely, thereby causing conditions that can only be met by individual consideration and the use of a special lubricant.

SYNTHETIC AMMONIA AND ALCOHOL SUPER-COMPRESSORS

Low Pressure Cylinders	TEXACO URSA OIL
High Pressure Service (*According to Pressure and Temperature*)	TEXACO URSA OIL HEAVY, or TEXACO URSA OIL EXTRA HEAVY

(*Continued on outside back cover*)

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Lubrication Requirements of Air, Refrigeration and Gas Compressors

COMPRESSION of various gases for industrial usage has become so distinctive a requirement in the manufacture of products essential to our modern civilization as to bring about a development in compressor manufacture, equal in interest to that of the steam turbine and Diesel engine.

The use of compressed air for the operation of pneumatic tools in mining, general manufacturing, and construction work presents a phase of compressor usage of importance only paralleled by the use of gas for our daily household needs or the application of ammonia and other chemicals to refrigeration purposes. In fact, the compressor today is even more of an essential to our comforts than the automobile. In this connection it is noteworthy to mention that the latter is virtually dependent upon the compressor, the variety of operations to which compressed air is applied being one of the distinct reasons for the success of mass production, from the initial blowing-in of the blast furnaces where the necessary start in steel manufacture is made, to the final application of paint with the spray gun.

The petroleum industry has likewise attained its prominence in conjunction with compressor development, the use of air being a factor throughout production and refinery processes, and even in distribution; viz., those certain types of air-operated grease lubricating systems.

A difference which exists in this relationship to the petroleum industry, however, is the distinct dependence of the compressor upon petroleum lubricants for effectual operation. In fact, had it not been for the concerted study of petroleum refiners relative to the peculiar lubricating requirements of the air, ammonia, and natural gas compressors, and the development of oils capable of meeting these requirements, it is safe to say that the use of the compressor would have been seriously restricted; for the compressor is one type of machine wherein straight mineral oils are primarily required; greases cannot be used, and fixed oil compounds involving animal or vegetable fats are only employed where special conditions of operation dictate.

It is, therefore, fitting to discuss the essentials of compressor lubrication with particular respect to the various gases being handled, machine construction, and the methods of application of lubricants.

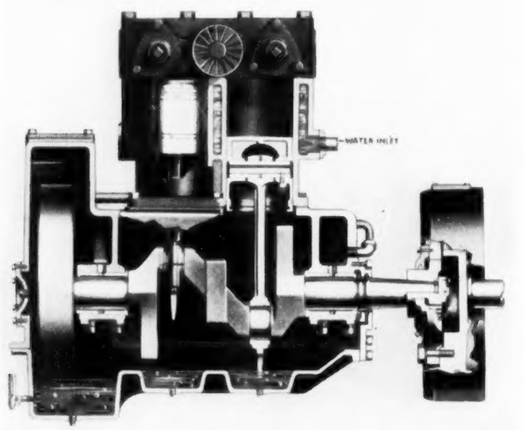
TYPES OF COMPRESSORS

One must, of course, understand the basic constructional features of the various types of compressors in order to appreciate more fully the subsequent remarks regarding lubrication. In effect, they can be broadly classified as reciprocating and rotary; the former class is generally further identified according to the particular type of construction, as it may involve single stage, multi-stage, or compound design.

Reciprocating Compressors

Where but one stage of compression is employed, the compressor is known as a single-

stage machine. It can be both single and double acting and may be either horizontal or vertical. Such machines are used for the compression of air up to approximately 80 pounds, or for handling of gas for household purposes, or refrigerants. Vertical single-stage compressors are generally of the one-cylinder, single-acting variety. The piston in these machines is usually of the trunk-type, the upper section carrying one or more rings which seal the cylinder and prevent excess oil from being drawn in or splashed, where they are designed for splash-lubrication. The lower portion of the piston usually carries one ring only. Vertical single-stage compressors are built in various sizes from one cubic foot capacity upward, although refrigerating compressors are based on tonnage. Horizontal single-stage compressors are of the one-cylinder, double-acting type.



Courtesy of Sullivan Machinery Company

Fig. 1—Cutaway view of the working parts of an air compressor, designed for portable service. Cylinder lubrication is effected by distribution of oil from the crankcase.

Multi-stage reciprocating compressors, wherein air or gas is subjected to two or more compressions, are used when pressures in excess of 80 pounds are desired. In compressors of this type after initial compression in the first cylinder, the air or gas is passed through an intercooler, which serves to reduce the temperature; it is then compressed in a second cylinder and so on in succession until the desired compression pressure is attained.

Because of the more effective cooling and because clearance losses are reduced, multi-stage compressors are more efficient in air compression service. Theoretically, therefore, the more stages, the higher the efficiency, but size and cost of machinery, as well as frictional losses, limit the number of stages to seven at the most.

Rotary Machines

Rotary compressors differ widely in design, but as a rule they use either sliding vanes in an eccentric housing or rotating gears or cams so arranged as to increase and decrease the enclosed air space alternately. This type has not attained such general application as the piston type, both because of the complexity of the moving parts and inability, as a general rule, to produce large volumes and high pressures as easily as the piston compressor. In certain specific cases, however, the rotary compressor is quite efficient and opportunity for future development is great.

Blowers

Blowers may be either of the centrifugal or rotary type. They are built to supply large quantities of air at low pressures. The centrifugal fan blower consists of a more or less scientifically designed "paddle-wheel," revolving in an eccentric casing. Such machines operate at pressures below one pound and are much used in heating and ventilating. Blowers of the bucket type develop along with the centrifugal action a certain pressure due to the shape of the bucket or blade. They may often impart a velocity to the air in excess of the peripheral speed of the rotor.

Blowing engines are very large, slow moving, reciprocating compressors which are employed principally in iron and steel plants for supplying large quantities of comparatively low pressure air to the blast furnaces. Blowing engines may be either horizontal or vertical in construction. As a rule they present no unusual lubricating difficulties.

Essential Requirements in Air Compressor Lubrication

Air compressor cylinder lubrication requires an oil which possesses certain very definite properties. It must not only lubricate effectively, but at the same time it must also resist decomposition when exposed to heated air; otherwise it might become a hazard due to possibility of explosion. Those properties which will indicate the ability of the oil to meet the above requirements are covered by the relative change in viscosity, the flash and fire temperatures, and the tendency to form carbon deposits.

The Effect of Relative Change in Viscosity

To understand the importance of viscosity, one must realize that the body of the oil will be subject to change in its relative fluidity with change in temperature. Due to the extent to which cylinder wall temperatures will vary, the viscosity of the oil used must, therefore, be given careful consideration; the degree of piston seal attainable can be judged by the indicated viscosity of the oil at operating temperature. This will in turn affect the efficiency of compression. Too light a bodied oil, i.e., one too low in viscosity at the operating temperatures in the cylinder, might easily result in its working past the piston rings to impair the seal; too heavy an oil would, in turn, tend to develop gummy matter which would in time result in the sticking of the piston rings or the vanes in certain types of rotary machines.

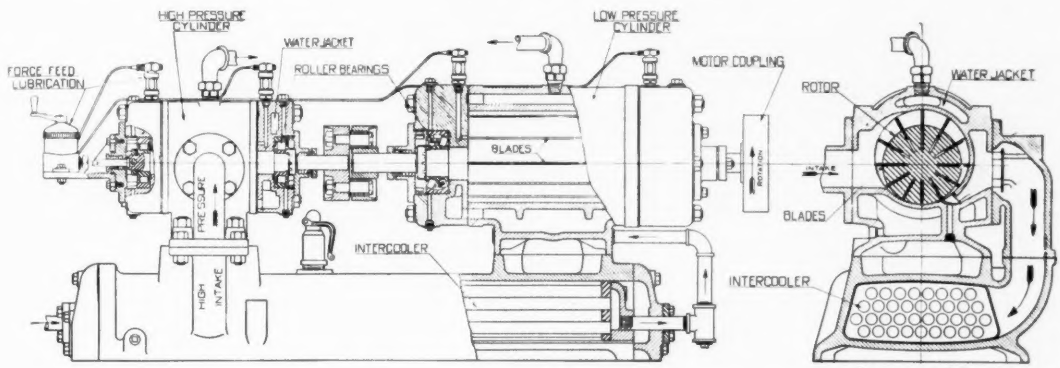
While an air compressor oil should, therefore, have a viscosity high enough to sustain the weight of the moving parts, and form a proper seal between the piston rings and cylinder walls, it should never be so heavy as to atomize with difficulty or develop excessive internal friction within itself.

Moreover, if too heavy an oil is used, the resultant oil film on the cylinder walls will more easily collect any dust that may be present in the air, and on the hot surfaces, to form carbon deposits. This is especially likely to happen when more oil has been used than just sufficient to lubricate the wearing surfaces, or where an air cleaner is not used.

Flash and Fire Points

The extent to which flash and fire points have been stressed by some in regard to their relation to effective compressor cylinder lubrication requires analysis of their actual importance. High flash and fire points have been decidedly over-emphasized in their relative importance as qualifications for air compressor lubricants. In fact, observation of the conditions under which explosions will tend to occur indicates that the possibility of formation of deposits within the compressor or air lines requires far more consideration.

The cause of such deposits has been mentioned above. In any installation where they are present and rendered incandescent for any reason whatsoever, an explosion may occur irrespective of the flash or fire points of the lubricating oil. Otherwise the oil would have to be submitted to a temperature much higher than its laboratory flash point before combustion could take place.



Courtesy of Fuller Company

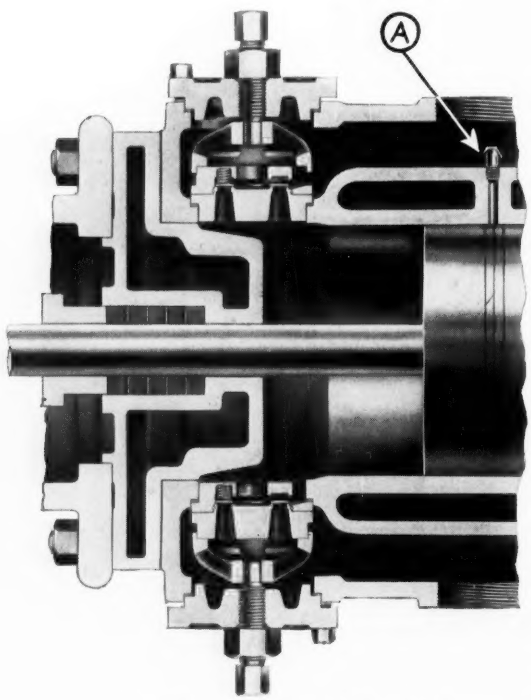
Fig. 2—The rotary type of two stage compressor equipped for force feed lubrication to all parts within the cylinder. Maintenance of a thin film of oil on the walls provides a running surface for the blades. The same oil must also lubricate the slots on the rotor in which the blades work.

It is also important to remember that compressor cylinder walls are generally cooled by water-jacketing, hence the temperature of the oil layer next to the wall will normally be but little above that of the wall itself. The outer oil layer exposed to the heated air, however, becomes much hotter than the rest of the oil body and a portion of it may be vaporized. As oils are composite mixtures, different portions will be distilled or vaporized at different temperatures. Certain of the lighter products may pass off even at temperatures below the flash point, leaving the heavy ends dissolved in the oil next to the wall. The final result, especially where an excess of high carbon content oil is used, may be oxidation and the building up of a gummy mass which has a low vapor pressure and high distillation point. As a result, the indicated carbon residue content should be studied as well as the degree of refinement of the oil.

Carbon Deposits—The Result of Oil Breakdown

Breakdown or decomposition, as mentioned above, is in part responsible for deposits of carbon plus dirt on the valves or in the discharge lines of an air compressor. It is im-

possible to get away from this phenomenon, for mineral lubricating oils, regardless of their base or nature, will decompose to volatile products and carbon when subjected to hot air under pressure. On the other hand, the extent of this decomposition will depend upon



Courtesy of the Pennsylvania Pump and Compressor Co.

Fig. 3—Showing constructional details of an air compressor cylinder. (A) indicates the point of entry of compressor cylinder oil. Note also the packing construction for piston rod.

the length of time the oil is exposed to such heat. Naturally, it will also follow that with oils of the same degree of refinement, the one which remains in the compressor cylinder or on the discharge valves the longest will form the greatest amount of carbon.

It is interesting to note that analysis of numerous so-called carbon deposits has proved them to consist more of dirt than of carbon, the whole being held together by gummy matter from decomposed oil, especially where the latter has been unsuited to the service involved.

Obviously an oil having a wide range of distillation, high end point, or too great a viscosity is objectionable, inasmuch as, instead of vaporizing cleanly, it breaks down as has been mentioned above, becoming sticky and collecting dirt brought in by the air. The slower the breaking down process, or the greater the volume of oil involved, the more carbon will ultimately be developed with greater possibility of subsequent trouble.

Manner of Formation

Carbon in its true form may develop in air compressor cylinders in a hard mass or it may be produced in the shape of dust and pass out with the air. In the latter case, it will often collect in pockets, elbows, or on sharp edges and become mixed with dirt taken in by the air as well as with oil which has been vaporized in the cylinder, and later condensed at these points.

Inasmuch as carbon is a poor conductor of heat, when deposited in cylinders it may become heated considerably above the temperature of the cylinder walls. This ultimately may be hazardous if allowed to continue. Furthermore, there will be a possibility of accumulations developing on the valves and valve seats, and in the ends of the cylinders. This may cause valves to leak, frequently resulting also in cutting of the latter and scoring of the cylinders.

Where deposits of dirt, gum, or carbon are allowed to collect in the valve passages and bends of piping to such an extent as to restrict the opening through which the compressed air has to pass, temperatures may be produced capable of eventually causing failure, especially if any part of the system is weak.

In view of the fact that pale filtered oils, where properly refined, show the least tendency toward direct carbonization and the development of carbonaceous matter, they are generally accepted as best suited to air compressor service. Furthermore, any such direct carbon as may be formed through excessive use of such oils is normally of a light, fluffy nature. Carbon deposits formed from improperly refined or unsuitable oils, on the other hand, are often of a hard, flinty nature. Any oil, however, will accumulate dust if the air is dirty and no provisions are made for filtration or cleaning.

METHODS OF AIR CYLINDER LUBRICATION

It is not only important, however, to select lubricating oils for air compressor cylinders which will have the proper viscosity, flash point, and low carbon content. The method of application will also be a decided factor in the subsequent attainment of effective lubrication.

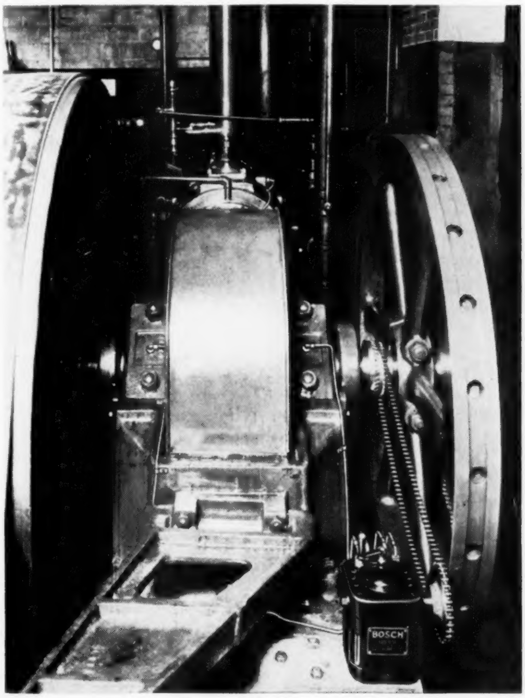
In fact, it is safe to say that granting the oil selected for air cylinder lubrication satisfies the requirements discussed heretofore, the possibility of future difficulties due to carbon formation will depend upon the method of feeding the oil and the quantity supplied.

Many authorities feel that this entire matter of effective air compressor cylinder lubrication hinges upon the amount of oil used. Any

excess supplied over that actually required will mean either:

(A) That this will be consumed by vaporization and breaking down in the compressor with the formation of a certain amount of direct carbon, or

(B) That it will be carried over with the air to collect subsequently in the intercoolers, the aftercooler or in pockets elsewhere in the system.



Courtesy of United American Bosch Corporation

Fig. 4—Showing a Bosch positive automatic force feed lubricator attached to a Worthington Feather Valve Air Compressor. Both cylinders and bearings are lubricated by this device.

Point of Delivery

In reciprocating machines, compressor oils will function best when completely atomized prior to being delivered to the cylinders. To effect such atomization in small and medium sized compressors the oil is often introduced at or above the point of air intake, the inrush of air carrying the atomized particles or spray of oil to all parts requiring lubrication. On account of the small amount of oil involved and the fact that a filtered oil is more readily atomized, the lubricator can in such cases be located fairly near the intake as atomization is effected in a relatively short distance of travel.

Air does not carry oil particles as readily as does steam. Horizontal compressors, therefore, may not receive sufficient oil at the uppermost parts of the piston and cylinder to insure sastifactory lubrication unless the oil feed is perhaps increased above the usual theoretical requirements. This is inadvisable, since the bottom part of the cylinder, being probably over-lubricated, will lead to the collection of oil in pockets, with ultimate carbonization.

In such cases, the procedure is to feed the oil directly to the sliding surfaces by means of sight-feed drip oilers or force feed lubricators. This, in fact, is customary practice on many large installations. Oil introduced in this manner is distributed to the cylinder walls by the wiping action of the piston.

The Force Feed Lubricator

Automatic pressure lubrication by means of a force feed lubricator whereby the flow of oil to the cylinder can be regulated is perhaps the most efficient and economical method available.

By use of this device the possibility of overfeeding oil to any particular part is reduced, oil flow stops and starts with the compressors, and the requisite lubricating and sealing film is more nearly assured.

Force feed lubricators are not affected by variations in air pressure, and they will feed the oil continuously in accordance with their adjustments and the speed of the compressor.

Type of Compressor Must be Considered

Of course, different types of compressors will naturally involve certain variations in their lubrication; in fact, they may even require radical departure from what are normally classed as standard methods in this regard. In general, however, the force feed lubricator, an arrangement for pressure circulation, or adaptation of the principles of splash lubrication must be used; the application, etc., being planned according to the recommendations of the compressor builder, based on the design of the machine, its size, capacity, and the character of the valves employed.

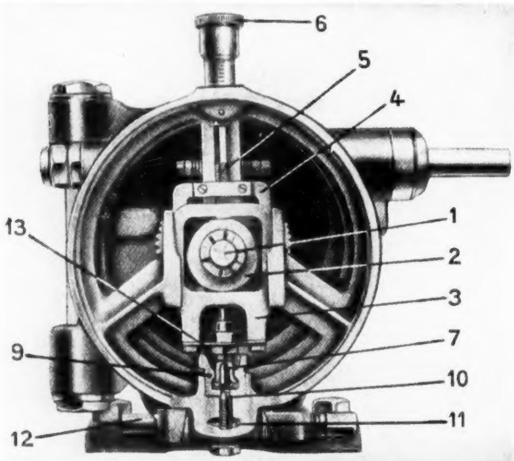
The operator or engineer, is, therefore, urged to consult with the builder of his machine either when planning on lubricator installations, etc., or when he feels his lubrication is faulty. As often as not, the oil is perfectly adapted to his machine requirements, the trouble being with the method of application.

Over-Lubrication a Detriment

It is inadvisable to establish any hard and fast rule in regard to the theoretically proper amount of oil that should be supplied to an air compressor cylinder. There are too many variables involved, such as the size of the compressor, its speed, and the condition of the piston and cylinder walls. The important point in any event is to guard against over-lubrication, inasmuch as more trouble will be caused by the use of too much rather than too little oil.

It must be remembered that oil will prob-

ably remain in an air compressor cylinder considerably longer than in the cylinders of either a steam or internal combustion engine, owing to the fact that there is little or no washing action or dilution of the oil film involved. As a consequence, very much less oil will be required



Courtesy of A. C. August Frisch, Apparatebau

Fig. 5—Constructional details of a Texaco-Frisch lubricator, designed for super-synthetic compressor service. 1—Stationary central axis. 2—Actuating cam. 3-4—Frames moved by cams. 5—Screw, the square stem of which slides in 6. 6—Milled head. 7—Piston (forms one piece with 4). 9—Seat of the valve. 10—Self acting valve. 11—Transverse channel. 12—Outlet tube. 13—Flexible steel plates.

per unit of cylinder surface over the same time interval.

It is a safe rule to use just enough oil to prevent frictional wear and to permit easy and free operation of all parts; more than this will lead to trouble.

Effects of Unsuitable Oils

If the lubricant is unsuitable, an excessive amount will be required to keep the pistons from groaning in the cylinders; in addition, the result of using an excessive amount of oil will be carbonization in the air passages, and particularly on the discharge valves. Sticking of these valves, with the passage of hot compressed air back into the compressor cylinder, is generally indication of over-lubrication. The discharge valves should therefore be examined regularly, and the aftercooler, receiver, or discharge pipes periodically blown out.

This will effectively remove any oil, water or sediment, which may have accumulated. If, upon removal, the discharge valves have a greasy appearance, enough oil is being fed to the cylinders; on the other hand, if the parts appear very oily or little pools of oil are found in compressor pockets, or in any of the air lines, oil is being fed in excess of that required, or has been improperly distributed.

Amount of Oil Required

There is a general rule to the effect that air compressors are sufficiently lubricated if one or two drops of the proper grade of oil are used for each 500 or 600 square feet of cylinder surface swept by the piston per minute. This rule, on the other hand, must be governed by the condition of the cylinders and the temperature and degree of compression.

The number of drops of oil which can be secured from a certain amount of any grade of oil will vary with the viscosity, temperature, service conditions involved and the diameter and shape of the lubricator orifice. As a result, the number of drops secured per minute from an oil having a Saybolt viscosity of 200 seconds at 100 degrees Fahr., would differ from the number secured from an oil of 300 seconds viscosity. Also, the type or design of the lubricator, i.e., whether mechanical, force feed or hydrostatic, would affect the number of drops obtained.

It is, therefore, not considered good practice to make an absolute recommendation as to the number of drops per minute that should be used in air cylinders of various sizes on account of the great variation in operating conditions that will be met.

In fact, two compressors of the same design, same size, and built by the same manufacturer, may be operating in a room under identical conditions, yet it will be practically impossible to secure the same fit of piston rings and valves and the same polished cylinder surfaces. Experience has shown that two such compressors may require a surprisingly different amount of oil for air cylinder lubrication.

In addition, the varying temperatures of the room will affect the feed of the lubricator, and while the operator may adjust the latter to give the same number of drops at different temperatures, with certain types of lubricators the difference in the size of the drops, and hence in the amount of oil fed to the cylinder, will be quite appreciable.

Synthetic Super-Compressors Lubrication

The necessity for higher pressures for the manufacture of synthetic ammonia and alcohol has led to the adoption of compressors ranging in pressure up to several thousand pounds, involving as many as seven stages. This advance has been especially noteworthy in Europe where the manufacture of synthetic products has become an economic necessity.

Ammonia Manufacture

In the manufacture of synthetic ammonia it will be of interest to note the general pro-

cedure. The raw materials used are first purified as much as possible in order to eliminate any sulfur compounds, moisture and other impurities which they may contain. In this regard as low as one part of sulfur to one million parts of gas has been found detrimental to the catalyst. They are then subjected to preliminary compression followed by cooling. The resultant purified products, i.e., hydrogen and nitrogen, are then led to the suction valve of the super-compressor in the proportion of three parts of hydrogen to one part of nitrogen.

It has been found necessary to employ seven stages of compression in this work, due to the comparatively high pressures which are essential. Abnormal temperatures are not met with, however, due to the efficiency with which intercooling is brought about after each stage. As a result, the temperature of the gases rarely exceeds 302 degrees Fahr., (150 degrees C.).

When the compressed hydrogen and nitrogen leave the super-compressor they are still only in the state of mixture. The actual formation of ammonia is brought about by passing them through a cylinder of special steel over a catalytic agent, at a reasonably definite temperature.

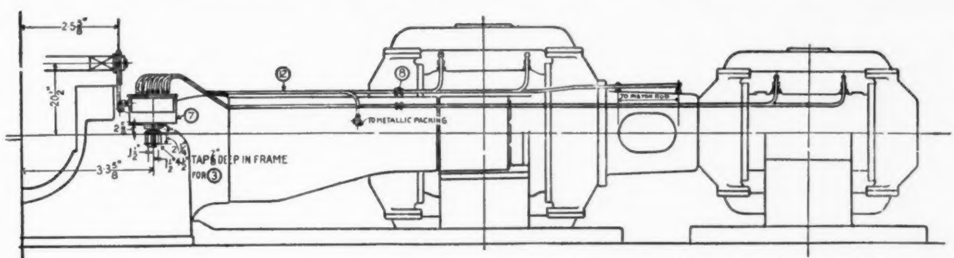
Lubrication Requirements

One of the problems in this operation is to prevent entry of lubricating oil into the catalyzing cylinder, for it has been found that the presence of oil materially affects the action of the catalyzing agent and reduces the output of the plant to a considerable degree. Such entry of oil can be prevented by installing oil traps between the distribution valve of the super-compressor and the catalyzing chamber. It stands to reason that the severity of the duty imposed on these traps will depend upon the amount of oil which is carried over by the gases from the super-compressor. To prevent abnormal entry of oil the utmost care must be taken in the regulation of the compressor cylinder lubricator. It has been developed that a straight mineral oil ranging from 900 to 1200 seconds Saybolt at 100 degrees Fahr., of as low carbon content as possible will best meet the load requirements of the compressors themselves, and maintain effective lubrication with minimum consumption. It must be borne in mind that heavier oils will separate more readily from the compressed gases than oils of lighter viscosity.

The fact that the use of compounded oils has been advocated by certain foreign authorities on super-compressor operation requires discussion of such products.

As a general rule, the only advantage which may pertain to the use of compound on this type of compressor work will be where high moisture content may prevail within the compressor cylinders. The undesirability of such moisture, however, has been fully realized by designers, and effort made to eliminate it as much as possible, so that the compressed gases will pass over the catalyst in a dry state.

Where a fatty oil, such as is usually employed for compounding, is present, it would be susceptible to change under high pressure and temperature, to result in gum formation and ultimate development of accumulations of carbon. Certainly these latter would not be desirable. It might be expected, of course, that due to the presence of hydrogen under pressure the formation of acids would be reduced, but this would not prevent the formation of various chemical compounds, or other changes in the fatty oil which, under the prevailing pressures, would not occur in a pure, highly refined, straight mineral oil.



Courtesy of Allis-Chalmers Manufacturing Company

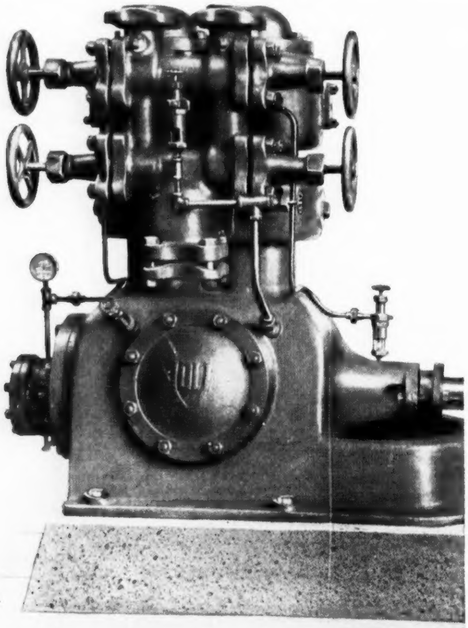
Fig. 6—Line sketch of an oiling system on a horizontal compressor. The mechanical force feed lubricator is shown at "7." Oil piping is indicated by heavy black lines.

Lubrication of Refrigerating Compressors

Study of the lubrication requirements of refrigerating machinery, as well as the means of application, should be given the utmost consideration, in the realization that one must consider not only the action and effects of the lubricants upon parts not requiring lubrication, but also the possible effect upon the actual wearing surfaces. The utmost care and judg-

ment must therefore be used in selecting such lubricants, and studying the limitations of the various means of lubrication in customary service.

In present day refrigeration practice splash and pressure lubrication predominate. Pressure can be applied to the lubrication of both vertical and horizontal machines. Splash lubrication, however, is more adapted to the vertical compressor. The system involved for the lubrication of compressor cylinders, stuffing boxes and enclosed bearings will have a decided influence upon the grade of the oil that should be used. It will, therefore, be of interest to study the principles involved in these methods of lubrication, as well as the essential constructional features.



Courtesy of I. P. Morris & De La Vergne, Inc.

Fig. 7—External view of a vertical ammonia compressor, equipped for force feed cylinder lubrication. Note piping leading to cylinders and stuffing box.

SPLASH SYSTEMS

In splash lubrication oil is distributed at each revolution of the crank, the level in the crankcase being maintained just high enough to permit the crank to dip and splash the necessary amount of oil to the cylinder walls and other contact surfaces. As the compressor continues to operate, the crankcase becomes filled with a lubricating vapor above the main body of oil, which will insure adequate lubrication of all main, wrist pin and crank pin bearings.

One must remember that careful attention is necessary, especially when re-charging the case with oil, to see that the level is not raised too high; otherwise, the oil would be churned by the crank, to bring about such violent agitation in the main body of oil as to preclude effective precipitation of any impurities that might have gained entry. There would also be a possibility of loss of lubricant past the piston rings, with subsequent entry of an excess of oil into the condensing and evaporating parts of the system.

Where piston rings are not sufficiently tight, it is also important to remember that if the crankcase contains too much oil, or if agitation is too violent, the excess which naturally will reach the cylinder walls will tend to work past the rings, as occurs frequently in automotive engine operation. This is often termed "oil pumping." Not only is it wasteful, but especially in an ammonia compression system will it be a detriment, for oil in the refrigerating lines will impose an added load on the oil separator. Furthermore, if by chance the oil is not of sufficiently low pour test, there will be a possibility of its congealing within the system, reducing refrigeration to a marked degree.

Excessive oil, in a splash lubricated system, will also involve the possibility of difficulty when draining and cleaning, especially where sludging has developed.

Sludge Formation

The possible detrimental effects of churning must be given consideration. Certain oils when so agitated in a crankcase will give rise to sludge formation if they have not been very highly refined. In part this is due to chemical reaction of ammonia with certain constituents of the oil. It will be most probable where water is present or the oil is laden with foreign matter, such as dirt, metallic particles or carbon, especially if too high a level is maintained.

In operation regular periods for cleaning should be observed, with careful investigation of the condition of the used oil, for this will very often indicate both the approximate suitability of the latter and the extent to which effective lubrication is being accomplished.

PRESSURE LUBRICATION

Where pressure lubrication is provided for, accurate control of the amount of oil delivered to cylinder walls and compressor bearings is made possible. On the other hand, any such system will require more equipment, piping, etc., and frequent filling of the reservoir (where a mechanical force feed lubricator is involved) and more attention from the operator than where splash lubrication is employed. On the other hand, pressure lubrication affords more

possibility of effective filtration or purification of the oil, especially where there is complete circulation.

The mechanical force feed lubricator is extensively used where compressor cylinders are to be pressure oiled. Excellent economy will be attained by regulating such lubricators so that just enough oil is delivered to maintain the requisite lubricating films, with drainoff reduced to a minimum.

There are many types of machines on which it is good practice to lubricate internal and external parts individually; in other words, using the mechanical lubricator with perhaps three outlets for cylinder and stuffing box service, and an independent gravity or mechanical pressure circulating system for all other moving parts.

Mechanical Force Feed Lubricators

Devices of this type are especially adapted to cylinder and rod lubrication via the oil lantern, or oil recess within the piston rod stuffing box. By properly constructing a stuffing box with a lead from the lubricator, it is possible to operate the piston rod continually through a ring of oil. In this way, effective rod lubrication can be maintained, as well as sealing against pressure.

Cylinder lubrication, in addition, can be accomplished by delivering additional oil to the stuffing box lantern and providing a so-called overflow pipe to carry this to the refrigerant suction line adjacent to the cylinder. In effect, this is similar to the principles of steam cylinder lubrication, the refrigerating gas being impregnated with vaporized lubricant prior to its passage through the machine.

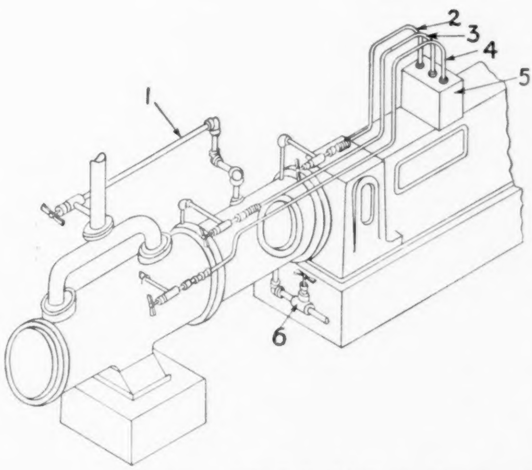
One could also use hand pump oilers for this purpose, but the mechanical force feed lubricator is more positive and requires less attention on the part of the operator.

Choice of lubricants for such service requires due regard for the service involved and the operating conditions that will probably be encountered. To overlook or to disregard the importance of such factors as the method of lubrication involved, the temperature in the expansion or refrigerating coils, the mechanical condition of the compressor, etc., and the location, type and efficiency of the oil separator may frequently lead to marked increase in maintenance costs and reduction in capacity as well as time lost due to shut-down.

CHARACTERISTICS TO BE CONSIDERED

From a lubricating point of view, pour test and viscosity command primary consideration, for it is these characteristics which will be indicative of the extent and degree of success with which any lubricant will function, in accordance with the particular operating and constructional conditions prevailing.

It is most important that an oil for refrigerating machinery lubrication shall remain fluid at the lowest temperatures to which it may be



Courtesy of The Carbondale Machine Company and Worthington Pump and Machinery Corporation

Fig. 8—Details of oil piping for double seal stuffing box on a Worthington horizontal compressor. 1 indicates vent from double seal chamber to suction; 2 is the oil feed to outer stuffing box; 3, the oil feed to inner stuffing box; 4, the oil feed to ammonia cylinder; 5, the 3-feed oil pump, and 6, the drain.

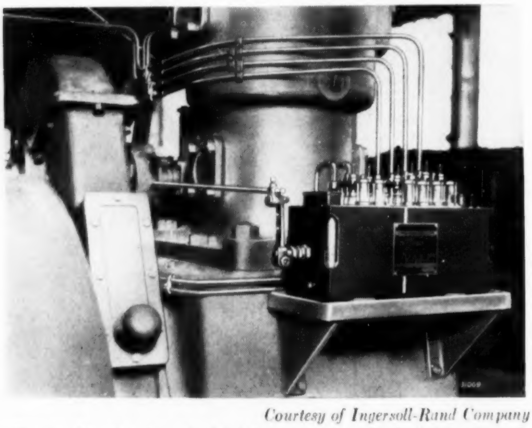
subjected during operation. These temperatures will be encountered beyond the expansion valve in the expansion or refrigerating side of the system. Many oils, of course, by virtue of their base and degree of refinement, will not be able to withstand lower temperatures without congealing to a certain extent, depending upon the amount of wax that may be contained and the pour test.

Where congealment occurs it indicates that a film of oil will be deposited on the inner surfaces of the refrigerating piping, to form more or less of an insulating medium which will prevent proper abstraction of heat from the compartment or medium which is to be cooled. If this is allowed to continue, it is evident that the refrigerating capacity of the system will be reduced and ultimately it will be necessary to clean out these congealed oil deposits, to develop the requisite production.

Possibility of congealment also requires that consideration be given to water. A refrigerating compressor oil should at all times be practically free from water, otherwise this latter may freeze if carried over to the refrigerator coils, in which case it would probably remain in the system and result in a certain decrease in evaporative efficiency and cooling capacity. The operator should, therefore, use the utmost care in placing oil cans beneath snow covered suction pipes, etc., or anywhere else where

moisture might splash or drip into the contents. An excess of water can readily cause so much trouble in the evaporator cells as to necessitate shut-down of the plant until this is eliminated.

For an oil to be suited to this class of service it should have a pour test sufficiently low to insure continued fluidity at the lowest temperatures prevalent in the evaporating side of the system. It should not congeal on the inner surface of the cooling coil, and there should be sufficient viscosity throughout the range of operating temperatures to enable it to serve at all times as an effective lubricant for the moving parts, as well as an adequate seal to prevent blow-by of gas past the piston rings.



Courtesy of Ingersoll-Rand Company

Fig. 9—Showing force feed lubricators and method of drive for cylinder lubrication of a gas compressor.

The Advantage of Filtered Mineral Oils

Straight mineral filtered oils having a viscosity of from 100 to 150 seconds Saybolt at 100 degrees Fahr., are entirely satisfactory where the temperature in the refrigerating coil is below 0 degrees Fahr. Above this temperature, however, an oil of somewhat higher viscosity, i.e., 200 to 300 seconds Saybolt, will give more protective lubrication.

One should always use the purest grade of straight mineral oil obtainable in order that the above requirements will be adequately met. Oils of this nature will have a sufficient range of physical properties to lubricate compressors effectively under all normal conditions of operation. Animal and vegetable oils are not suitable for such service inasmuch as they will have a tendency to congeal at low temperatures and gum at higher temperatures. They will also react to a certain extent with ammonia, to cause the formation of sludge and detrimental deposits.

Particular attention should be given to viscosity where enclosed crankcase, high speed machines of the wet compression type are involved. As a rule, oils should be used which will stand considerable churning in the presence of the refrigerant and a certain amount of water vapor. Here one oil lubricates the entire machine. As a result, it must be capable of serving both the cylinders and bearings. It should not emulsify to any great extent, for this might result in clogging of the lubricating lines, or impairment of refrigeration should it work past the piston rings and over to the refrigerating side of the system.

From a mechanical point of view the seal and compression forming ability of an oil is practically as important as its lubricating properties. If the cylinder wall and moving parts are in first-class condition, a straight mineral oil of approximately 200 seconds Saybolt viscosity at 100 degrees Fahr., will be suitable.

Where cylinder walls and rings are worn or scored, the viscosity must be higher, commensurate with the pour test, to maintain the requisite seal and degree of compression. Usually an oil having a viscosity of 300 seconds Saybolt at 100 degrees Fahr., will be satisfactory in this event. Obviously, therefore, the physical condition of the valves, piston rings and stuffing boxes must always be considered in deciding upon the viscosity.

There will be greater tendency for horizontal compressor cylinders to wear out of round than those of vertical machines. In consequence, such compressors will, in general, require a somewhat heavier lubricant. It is not advisable, however, to attempt to compensate for wear by increasing the viscosity too much, due to the possibility of emulsification, contamination of the refrigerant and reduction in cooling capacity.

Gas Compressor Lubrication

In the lubrication of compressors devoted to the handling of gas in either its natural or synthetic form, the question of contamination, sulfur content and the possible effect upon the resultant product must be given equal consideration, along with the possible washing effect of the gas itself, especially when wet or rich in liquefiable hydrocarbons.

Compressors are used for the handling of either natural or producer gas in the course of

preparing these products for direct consumption, or in the manufacture of gasoline from the former.

Natural gas is procured from wells which may or may not produce crude oil. Various pressures exist according to the locality and type of well. Instances are known where the well pressure at ground surface has run as high as 3000 pounds. While such gas, dependent upon the source, may be comparatively dry, in the green or wet form, it may contain from one-half to four gallons of so-called casinghead gasoline or a heavier product, known as mineral seal oil, similar to kerosine, per thousand cubic feet of gas.

Oftentimes under such conditions, should the lubricating system be functioning improperly, this liquid may exert a distinct washing action upon the cylinder walls; due to its nature, it will tend to cut or dissolve the lubricating film.

The possibility of discoloration of the finished gasoline, where such gas is used for the manufacture of this product by compression alone, must also be considered. In this connection the use of highly refined pale filtered oils is of advantage especially where the feed rate is high.

Certain grades of natural gas may also carry an appreciable percentage of sulfur, which may exist in the corrosive form. Here, in turn, the effect upon compressor parts must be considered, and the lubricant chosen for its protective as well as its lubricating properties. The former can often be improved by increasing the rate of oil feed.

Producer gas, in turn, may contain more or less soot, which also will have its effect upon lubrication. General practice is to remove the more or less solid impurities by passing the gas through traps or scrubbers prior to the first compression stage, in the interest of protecting the compressor parts as far as possible.

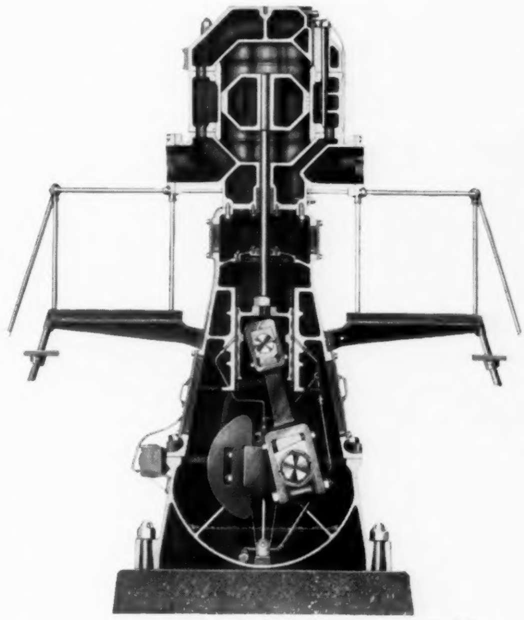
In the handling of natural gas, following each stage of compression, and aftercooling, any liquid gasoline which is condensed is removed from the system by means of traps similar to those used on steam lines for the removal of water.

By reason of the nature of the gas, lubrication of compressors in such service requires consideration from two distinct angles, viz.:

(a) Where the gas is maintained in its true gaseous condition, and

(b) Where the original gas is partly liquefied, or by virtue of compression is converted in part to liquid form.

As a general rule, lubrication of wet compressors, where more or less gas is in the liquid state, will require more careful consideration than where dry gas is involved, for the reason that the washing action of the liquefied gas on the cylinder walls may affect the maintenance of a suitable film of oil.



Courtesy of Chicago Pneumatic Tool Company

Fig. 10—Sectional side view of a vertical compressor. Note the cylinder lubricators on the left, and the removable cylinder liners. This machine is especially adapted to gasoline extraction and the compression of "wet" gases.

WET GAS OPERATIONS

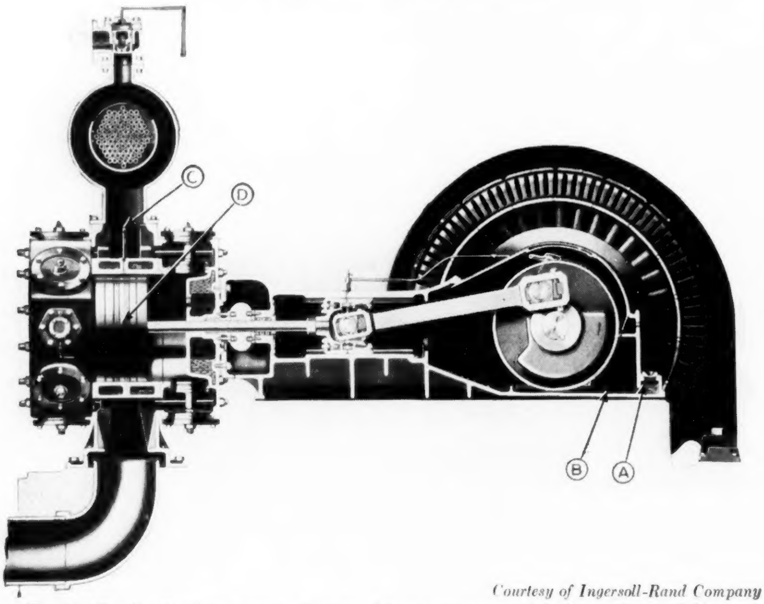
The condition which exists is much the same as that which is encountered in the lubrication of steam cylinders where saturated steam is used.

The actual reaction in a gas compressor cylinder, however, is somewhat different than in a steam cylinder. In the latter, a lather is developed by reaction of the moisture content of the steam with the fixed oil in the lubricant. Where gas is being handled, on the other hand, effective lubrication can be accomplished by increasing the rate of oil feed as well as the viscosity of the lubricant. Certain operators, however, have a preference for compounded oils.

The amount of fixed oil compound to use in such an oil will, in general, be governed by the amount of liquefiable hydrocarbons as well as the moisture contained by the gas. Normally 3% of lard oil will suffice to promote maintenance of an adequate film of lubricant, provided it is properly compounded with a highly refined mineral oil. On the other hand, when the gas is excessively wet, the use of from 10 to 20 percent of rapeseed oil in com-

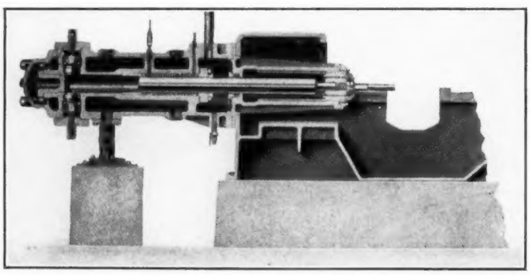
pound has been found to promote effective lubrication, especially when used with a comparatively heavy mineral oil base.

The viscosity of this latter should be studied with due regard to the compression pressures and the nature of the gas. Use of higher viscosity oils has been found to promote economy in the amount required. Furthermore, such oils can be assumed to be more adhesive, especially under casinghead gasoline extraction operations, or wherever a considerable amount of liquid gas is present or developed in the course of compression. One should guard against the use of excessively heavy oils, however, due to the possibility of formation of deposits on cylinder walls and valves which might lead to retarded valve action and excessive wear on cylinder walls and piston rings.



Courtesy of Ingersoll-Rand Company

Fig. 11—Details of a direct connected motor driven compressor. A is the crankcase oil filler and oil level indicator; B the provision for flood lubrication of the external bearings; C the inlet to the cylinder from the force feed lubricator, and D the piston rings for maintaining a seal.



Courtesy of Clark Brothers Company

Fig. 12—Sectional view of a high pressure compressor cylinder, employed for the handling of high pressure gases. Note constructional details and points of application of lubricants.

DRY GAS REQUIREMENTS

Where either natural or producer gas has been treated, however, to dry it before compression, lubrication of compressor cylinders will be essentially the same as where air is being handled.

Compression of either natural or producer gas for normal usage does not require high pressures, therefore temperatures are lower than in average air compressor service. For this reason, heavy bodied oils are not required, a straight mineral 300 to 750 viscosity product being suitable. Under higher pressures, however, temperatures of compression will be increased just as in the case of air compressor operation. Normally these will not exceed 350 to 400 degrees Fahr. Under such temperatures a 500 second viscosity oil could be expected to give best economy and resist reduction in film tenacity, due to the higher temperatures. It is essential to remember, however, that the oil must always be highly refined, otherwise objectionable carbon deposits and gummy matter may develop. Where the gas being compressed is free from soot or other impurities, the sparing use of a properly refined straight mineral oil will insure efficient operation indefinitely.

The mechanical force feed lubricator has been proved a most adequate means of delivering oil to compressor cylinders, in as nearly as possible the right amount, commensurate with the nature of the gas, to insure dependable and continuous operation.

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